

# Higgs signal in Chargino-Neutralino production at the LHC

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We have analyzed the prospect of detecting a higgs signal in mSUGRA/CMSSM based Supersymmetric(SUSY) model via chargino-neutralino( $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ ) production at 8 TeV LHC energy. The signal is studied in the channel with  $\ell + b\bar{b} + \cancel{p}_T$  following the decays,  $\tilde{\chi}_1^\pm \rightarrow W^\pm \tilde{\chi}_1^0$ ,  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 h$  and  $h \rightarrow b\bar{b}$ . In this analysis reconstruction of the higgs mass out of two b-jets plays a very crucial role in determining the signal to background ratio. We follow two techniques to reconstruct higgs mass: (A) using two identified b-jets, (B) using jet substructure technique. In addition, imposing a certain set of selection cuts we observe the significance is better for the latter method. We find that a viable signal can be obtained for the higgs mass  $\sim 125$  GeV with an integrated luminosity  $100 \text{ fb}^{-1}$ .

## 1. INTRODUCTION

The quest for the higgs boson is one of the high priority programme of the LHC experiment. Recently, both ATLAS and CMS group have published preliminary results on higgs searches accumulating data of luminosity about  $5 \text{ fb}^{-1}$ . They have constrained the light higgs mass within the range of 115 - 130 GeV at 95%C.L [1] consistent with the predictions based on electro-weak precision measurements [2]. However, interestingly both the groups have also reported a modest excess of events around the higgs mass,  $m_h \sim 125$  GeV over the Standard Model(SM) backgrounds [1], although it is not very convincing as an evidence for a higgs signal. Results with more higher luminosity will confirm it in future, may be by the end of this year when LHC machine is expected to run with 8 TeV energy.

In this letter we investigate the implications of higgs searches mentioned above assuming that the observed excess of events are indeed hints of a higgs signal. As we know, many models of beyond standard (BSM) physics also predict the existence of the higgs particle. For instance, the Minimal Supersymmetric Standard model(MSSM) contains five higgses, two CP even higgs h,H, one CP odd higgs A and two charged higgs  $H^\pm$ . In the tree level, unlike SM, the masses of all higgses in MSSM can be predicted in terms of  $m_A$  and  $\tan\beta$  which is the ratio of vacuum expectation values of the two higgs doublets required to generate masses of fermions. The mass of the lightest higgs( $m_h$ ) is bounded by  $m_h \lesssim m_Z$  [3] at the tree level, but loop corrections enhance this limit up to  $m_h \lesssim 140$  GeV [3]. Notice that this theoretical upper limit is consistent with the present limits set on the higgs mass by LHC experiments. Moreover, in the decoupling regime,  $m_A \gg m_Z$ , the lightest higgs(h) becomes SM like. Evidently, there is a correlation between  $m_h$  and masses of sparticles and in turn model parameter because of huge loop effects in SUSY. The dependence of  $m_h$  on model parameters including recent higgs mass constraints are discussed by a number of authors in the framework of

constrained MSSM(CMSSM) or the minimal supergravity(mSUGRA) [4, 5] model and also other variations of SUSY models [4]. The mSUGRA model is described by four parameters at the GUT scale,  $m_0$ ,  $m_{1/2}$ ,  $A_0$ ,  $\tan\beta$  and sign of  $\mu$ , where  $m_0$  is a soft unified mass for all scalars,  $m_{1/2}$  is the unified gaugino mass and  $A_0$  is the universal trilinear coupling. The lightest higgs mass is sensitive to  $m_0$ ,  $A_0$  and  $\tan\beta$ , as the square of the third generation squark mass matrix which contributes dominantly to the loop correction are controlled by those parameters. A detailed scan of parameter space shows that the current constraints on the higgs mass from LHC experiments is compatible with the certain regions of parameter space in mSUGRA/CMSSM. For example, for low  $m_0(\leq 4 \text{ TeV})$  case, to achieve  $m_h \sim 125$  GeV, a high value of  $A_0$  is required, whereas for high  $m_0 \sim 4 \text{ TeV}$ , one needs a moderate value of  $A_0$  [4, 5]. As a consequence, the parameter space in mSUGRA allowed by higgs mass constraints predict the masses of sfermions(squarks and sleptons) to be of multi-TeV range. However, the mass of top squark( $\tilde{t}_1$ ) remains comparatively lighter because of mixing effects and is likely to be accessible within the LHC energy range along with gauginos(charginos and neutralinos) and gluinos [5]. It is worth mentioning here that from negative searches, both ATLAS and CMS exclude a region in the  $m_0 - m_{1/2}$  plane implying a limit,  $m_{\tilde{g}} \gtrsim 1.1 \text{ TeV}$  for  $m_{\tilde{q}} \sim m_{\tilde{g}}$  case, and  $m_{\tilde{g}} \gtrsim 700 \text{ GeV}$  for  $m_{\tilde{q}} \gg m_{\tilde{g}}$  scenario [6].

In this paper, we explore the detectability of higgs signal in SUSY cascade decay chain which may indicate the existence of a SUSY higgs. With this motivation we investigate the higgs signal in chargino( $\tilde{\chi}_1^\pm$ ) and second lightest neutralino( $\tilde{\chi}_2^0$ ) pair production following the dominant decay of,  $\tilde{\chi}_1^\pm \rightarrow \tilde{\chi}_1^0 W^\pm$  and  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 h$ . The discovery of a higgs signal in SUSY cascade decays has been studied previously in detail by the authors of Ref. [7]. It is well known that in hadron colliders, strongly interacting colored sparticles,  $\tilde{g}$  and  $\tilde{q}$  are produced copiously. The current exclusions by the LHC experiments from SUSY and higgs searches in mSUGRA favor high  $\tilde{q}$

	$m_{1/2}$	$\mu$	$m_h$	$m_{\tilde{g}}$	$m_{\tilde{q}}$	$m_{\tilde{t}_1}$	$m_{\tilde{\chi}_1^0}$	$m_{\tilde{\chi}_2^0}$	$m_{\tilde{\chi}_1^\pm}$
P1	300	1541	122.4	865	3000	1305	133	265	265
P2	380	1660	122.8	1046	3060	1335	168	332	332
P3	450	1653	123.2	1200	3096	1370	198	390	390

TABLE I: Masses of some of the sparticles for three benchmark points. For each case  $m_0 = 3000$ ,  $\tan\beta=30$ ,  $A_0=-4500$ . All energy units are in GeV.

and  $\tilde{g}$  masses ( $m_{\tilde{g}} \sim m_{\tilde{q}} \sim 1\text{TeV}$ ). Therefore, for this range of  $\tilde{g}$  and  $\tilde{q}$  mass, the  $\tilde{g}$  pair production is expected to dominate over the  $\tilde{q}$  production. Eventually, the higgs boson may arise in  $\tilde{g}$  cascade decay chain via heavy flavors, i.e.  $\tilde{g} \rightarrow t\tilde{b}\tilde{\chi}_1^\pm, t\tilde{t}\tilde{\chi}_1^0, t\tilde{t}\tilde{\chi}_2^0$  and  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 h$ . We examined that the probability of finding higgs events via  $\tilde{g}$  pair production and its subsequent cascade decay is  $\sim 1\text{-}3\%$ . Moreover, with the increase of  $\tilde{g}$  and  $\tilde{q}$  masses, strong production cross sections drop significantly ( $\sim \text{few fb}$ ) and electro-weak gaugino pair production takes over. In view of this fact, we consider  $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$  pair production to probe the higgs signal instead of  $\tilde{g}$  pair production. The detection of higgs signal in this channel has not been studied before for 8 TeV LHC energy. It is to be noted that the  $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$  production is regarded to be a promising SUSY discovery channel through a clean trilepton signal. Recently, this channel has also received a lot of attention to probe SUSY signal [8, 9] at the LHC due to the higher limits on  $\tilde{g}$  and  $\tilde{q}$  masses [6]. Similar analysis has also been performed for LHC in the paper of Ref. [10] for 14 TeV energy. The higgs production via  $\tilde{t}_1$  production and its subsequent decays has also been discussed in [11].

In mSUGRA, at the GUT scale masses of all gauginos are given by  $m_{1/2}$  and at the electro-weak scale they are related as  $M_2 \simeq M_3/3 \sim m_{\tilde{g}}/3$  and  $M_1 \simeq M_2/2$  because of renormalization group evolution(RGE). Here  $M_1$ ,  $M_2$  and  $M_3$  are the U(1), SU(2), SU(3) gaugino mass parameters respectively. In order to find the appropriate parameter space in mSUGRA, we scan the entire range of parameter space using SuperIso [12] imposing constraints from  $b \rightarrow s\gamma$ ,  $B_s \rightarrow \mu^+\mu^-$ ,  $(g-2)_\mu$  [5] and the higgs mass limit 122-126 GeV. In figure 1, we show in the  $m_{\tilde{\chi}_1^\pm} - m_0$  mass plane (left panel), the allowed regions (shaded) for  $\tan\beta = 30$ . This figure clearly indicates that  $m_{\tilde{\chi}_1^\pm} \sim 200$  GeV or more are allowed corresponding to a very high squark mass (i.e.  $m_0 > 3\text{TeV}$ ). To get a reasonable branching ratio for the decay  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 h$  we select parameter space where  $|\mu|$ , the higgs mass parameter is very large leading to the lighter  $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$  and  $\tilde{\chi}_1^0$  states being gaugino dominated. Therefore, for very high values of  $|\mu|$ ,  $|\mu| \gg M_2, M_1$ ,  $m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^0} \sim M_2 \sim M_{\tilde{g}}/3$ . Hence, in view of the current limit on  $\tilde{g}$  mass,  $m_{\tilde{\chi}_1^\pm}$  and  $m_{\tilde{\chi}_2^0}$  are expected to be around 250 GeV or more. For the sake of presentation of our results we select three benchmark points (P1-P3) corresponding to very low and high values of gaugino masses which are presented in Table I. For this region of parameter space,  $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 h$  branching ra-

tio(BR) is more than 80% branching ratio and the  $h \rightarrow b\bar{b}$  BR is about 70%.

In section 2 we discuss our simulation strategy for signal and backgrounds and present results in section 3 and finally summarize our study in section 4.

## 2. SIGNAL AND BACKGROUND

We investigate the higgs signal in SUSY cascade decay,  $pp \rightarrow \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow (\tilde{\chi}_1^0 W^\pm)(\tilde{\chi}_2^0 h)$ , leading to a final state with a hard lepton ( $e, \mu$ ) from W decay and two b-jets from higgs decay and a large  $p_T$  due to the presence of  $\tilde{\chi}_1^0$  and  $\nu$ , but without any additional jet. The identical final state may also come from  $t\bar{t}$ ,  $Wb\bar{b}$ ,  $Zb\bar{b}$ ,  $WZ$ ,  $Wh$ ,  $Zh$ ,  $tb$ ,  $tbW$  processes. Recall that the  $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$  pair production cross sections (c.s) are about 10-150 fb depending upon gaugino masses, in contrast to background cross sections which vary from few picobarn (pb) to more than 100 pb. Thus a huge suppression of background events is required to achieve a reasonable sensitivity, which is a challenging task. The added advantage is that the invariant mass constructed out of two b jets is expected to show a peak at the higgs mass, which can be exploited to identify the signal region. Therefore, a good reconstruction of higgs mass out of two b jets is one of the crucial issue to be studied in this analysis. In this letter we report about the simulation of signal and backgrounds adopting two methods for higgs reconstruction. In the first method (Method A) we identify two b-jets out of all jets in the events and obtain the higgs mass by calculating the invariant mass from two identified b-jets. In the second method (Method B) reconstruction of higgs mass is performed by using jet substructures which will be discussed later. Eventually, we present our results for both cases, method A and B.

In our simulation signal and background ( $t\bar{t}$ ,  $WZ$ ,  $Wh$ ,  $Zh$ ,  $tb$ ,  $tbW$ ,  $Wb\bar{b}$ ,  $Zb\bar{b}$ ) events are generated using PYTHIA [13] and ALPGEN [14] with PYTHIA used for showering for  $Wb\bar{b}$ ,  $Zb\bar{b}$ ,  $tb$ ,  $tbW$  process. We adopt MLM matching [15] to avoid double counting while performing parton showering after matrix element calculation. We interface FastJet for jet reconstruction using built in anti- $k_T$  algorithm with  $\Delta R=0.5$  [16] in method A, whereas Cambridge-Aachen [17] algorithm is used for method B. We use CTEQ6L as parton distribution function while calculating cross sections [18]. We use SuSpect interfaced with SUSYHIT to calculate SUSY mass spectrum and corresponding branching ratios [19].

We observe that use of higgs mass reconstruction alone is not enough to eliminate backgrounds substantially. A certain set of selection cuts described below are necessary to reject backgrounds.

- Lepton : Leptons ( $e$  and  $\mu$ ) are selected with  $p_T^\ell \geq 20$  GeV and  $|\eta| \leq 2.5$ . Isolation of leptons are ensured by checking the total transverse energy  $p_T^{AC} \lesssim 20\%$  of  $p_T^\ell$ , where  $p_T^{AC}$  is the scalar sum of transverse energies of

jets close to leptons satisfying  $\Delta R(\ell, j) \leq 0.2$ . We veto events if there exist a second lepton with a loose criteria of  $p_T^\ell \geq 10 \text{ GeV}$ , primarily to suppress top background.

- **Jets:** Jets are selected using **FastJet** [16] with a  $p_T \geq 50 \text{ GeV}$  and  $|\eta| \leq 3$  ( $|\eta| < 2.5$  for method B).

- **b-Jets:** b like jets are identified by performing matching jets with b quarks assuming a matching cone  $\Delta R(b, j) = 0.5$ . In addition, we require that the matched b jet momenta should have at least 80% of the b quark momenta. A proper method of b-tagging using displaced vertex is beyond the scope of this analysis. Finally, we multiply by a b-tagging efficiency 70% [20] for each b-tagging i.e  $\epsilon_b^2 = 0.5$  for two b-tagged jets while estimating total event rates.

- $p_T$ : Missing transverse momentum is calculated out of all visible stable particles. The  $p_T$  in the signal arises mainly due to the massive  $\tilde{\chi}_1^0$  and  $\nu$  as well, whereas in background events, it solely arises from  $\nu$  in W decay. Nevertheless, the hardness of  $p_T$  in signal is not significantly different than the large  $t\bar{t}$  background making it very difficult to distinguish the signal from the background.

- $R_T^{bb}$ : We define a very robust variable which is extremely efficient in eliminating backgrounds by huge fraction as discussed in a previous analysis [21]. It is defined as the ratio of scalar sum of  $p_T$  of two b-jets and sum of all jets in the events i.e  $R_T^{bb} = \frac{p_{T1}^{bb} + p_{T2}^{bb}}{H_T}$  where  $H_T$  is the scalar sum of  $p_T$  of all jets passing pre-selection criteria. We define this variable keeping in mind that in the signal process no hard jets are expected except two b-jets from higgs decay. Of course, few jets may arise from initial and final state radiations, but the number of jets with  $p_T \geq 50 \text{ GeV}$  is expected to be low and soft. Hence  $R_T^{bb}$  turns out to be  $\sim 1$  for signal. In backgrounds, particularly in top pair production there are additional hard jets arising due to the hadronic decay of W (since we are giving a veto on the second lepton) resulting in  $R_T^{bb} < 1$ . Thus a judicious choice of a cut on  $R_T^{bb}$ , suppresses backgrounds enormously without affecting the signal.

- $\phi^{bb}$ : The azimuthal angle  $\phi^{bb}$  is defined as the angle between two b-jets in the transverse plane. In the signal process the angle is expected to be small, but in backgrounds, for example in top pair production they are in general widely separated. It has to be emphasized here that with the increase in  $\tilde{\chi}_2^0$  mass, the  $h \rightarrow b\bar{b}$  system gets boosted and the b jets become almost collinear which is a perfect recipe for a jet substructure analysis which are described in the following section. However we find that a reasonable cut on  $\phi^{bb} \leq 2$  considerably suppress the background by a large extent.

- $m_T(\ell, p_T)$ : The transverse mass defined as  $m_T = \sqrt{2p_T^\ell p_T (1 - \cos \phi(\ell, p_T))}$ , where  $\phi(\ell, p_T)$  is the azimuthal angle between lepton and  $p_T$  direction. The value of  $m_T(\ell, p_T)$  is expected to be restricted by W mass if both leptons and  $p_T$  originate from W decay, which is the case for backgrounds, particularly for  $t\bar{t}$  and  $Wb\bar{b}$  channels. Therefore, a reasonable cut on  $m_T(\ell, p_T)$  is found to be effective to reduce background level.

- $m_{b\bar{b}}$ : As mentioned above the invariant mass of two b-jets is very useful in isolating signal region. In method A, this reconstruction is straight forward and is performed using two b-jets momenta obtained by matching b-jets with b-quarks. However, in method B, we use jet substructures to find b-jets inside a "fat-jet" due to higgs decay. The use of jet substructure for the reconstruction of hadron decays of boosted W, Z, higgs boson and top quark has received considerable attention in recent years and the available literature is steadily increasing [22]. In our present study this method was motivated following the work of Ref. [23] where the authors reconstructed the higgs mass using jet substructures to increase the signal sensitivity. Along the same line of argument we resort to the same method to reconstruct higgs mass. The efficiency of jet substructure technique depends on the boost factor of the decayed object. A highly boosted system ensures that decay products are well collimated and appear as a "fat-jet". However, in the scenario of interest to us higgs is moderately boosted as its  $p_T$  depend on  $\Delta m = m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ . In our analysis we first cluster all the stable final state particles into a "fat jets" using the C/A algorithm [17] with  $R = 1.2$  as implemented in Fastjet [16]. We select "fat jets" with  $p_T \geq 100 \text{ GeV}$  and  $|\eta| < 2.5$  and then perform jet substructure analysis. There are various methods of finding jet substructures [22]. In this analysis we use mass drop(MD) method optimising two input parameters,  $\mu = 0.4$  and  $y_{\text{cut}} = 0.1$  which are described in the paper [23] and also coded in **FastJet** package [16]. In the simulation we use PYTHIA event generator by setting Tune Z2 parameters described in Ref. [24] for underlying event modeling. In Figure 1, in the right panel we show the reconstructed higgs mass following method A (blue) and B (red) corresponding to parameter space P2. This figure clearly demonstrates the robustness of higgs mass reconstruction by using jet substructures. In case of method A, some of the soft jets incidentally passing the matching criteria resulting in a spread towards the lower side, whereas in the jet substructure method this type of contamination are avoided by filtering out those contributions to jets [23].

### 3. RESULTS

**Method A:** In this section we discuss the simulation strategy of signal and backgrounds by reconstructing the higgs mass out of two identified b-jets obtained by matching techniques as discussed above. In order to eliminate SM backgrounds additional cuts are applied with the following requirements:

- $R_T^{bb} \geq 0.7$ ,
- $m_{b\bar{b}} = 110-130 \text{ GeV}$ ,
- $p_T \geq 175 \text{ GeV}$ ,
- $\phi_{b\bar{b}} \leq 2$ .

In Table III we present event summaries of signal for three benchmark points shown in Table I, along with backgrounds after applying these set of cuts. The second and third column present the raw leading

Process	$\sigma(\text{pb})$	$N_{EV}$	$1\ell$	$R_T^{b\bar{b}}$	$m_{b\bar{b}}$	$\not{p}_T$	$\phi_{b\bar{b}}$	c.s.
			2b-jets	$\geq 0.7$	110-130	$\geq 175$	$\leq 2$	(fb)
P1	0.175	0.1M	1392	1162	723	92	76	0.065
P2	0.065	0.1M	1767	1478	933	217	178	0.06
P3	0.03	0.1M	2142	1774	1122	424	391	0.055
Wh	0.58	50K	702	594	394	8	2	0.01
Zh	0.3	50K	210	162	51	1	1	0.003
$Wb\bar{b}$	3	619685	26841	24513	2269	8	3	0.014
$Zb\bar{b}$	1.75	378098	3863	2937	269	0	0	0.
$t\bar{t}$								
5-100	48.2	4M	207335	94337	10145	0	0	0.
100-200	36.3	2M	158450	50967	1205	8	1	0.01
200-500	9.5	1M	134238	22473	116	42	4	0.02

TABLE II: Event summary for signal and backgrounds(method A) after each set of cuts described in the text. The  $t\bar{t}$  events are simulated for different  $\not{p}_T$  bins as shown. Efficiency for two b-tagged jets is multiplied in the last column. The energy units are in GeV.

order(LO) cross section(c.s) and number of events simulated respectively. In the fourth column, we present the number of events requiring one single hard lepton along with two identified b-jets including lepton veto as well. Although we simulated all possible SM backgrounds including QCD, tb, tbW, but we present results only for non-negligible contributing channels. It clearly demonstrates that the  $R_T^{b\bar{b}}$  cut is very effective in reducing backgrounds by an enormous amount, but except for those channels, like  $Wb\bar{b}$ , Wh. Selection of events in the higgs mass window between 110-130 GeV is also useful to remove backgrounds keeping almost more than 50% signal events. Finally, a very strong  $\not{p}_T$  cut is used to eliminate remaining backgrounds, but at the cost of a sizable signal cross section; nevertheless we retain a good number of signal events. After all cuts, we find the total background cross section is about 0.057 fb with dominant contribution from  $t\bar{t}$ , whereas signal cross sections are of the range of 0.065-0.055 fb. In both cases we use LO production cross sections. However, if we use NLO cross sections by multiplying K-factors which is  $\sim 1.5$  for signal [25] and about 1.6 for  $t\bar{t}$  [26], then assuming a luminosity  $100 \text{ fb}^{-1}$ , one can expect  $S/\sqrt{B}$  about 3.5 for this mass range of  $\tilde{\chi}_1^\pm$  and  $\tilde{\chi}_2^0$ .

**Method B:** In this method we apply jet substructure technique in reconstructing higgs mass with additional cuts as before to control background events.

- $m_T(\ell, \not{p}_T) \geq 90 \text{ GeV}$ ,
- $R_T^{b\bar{b}} \geq 0.9$ ,
- $\not{p}_T \geq 125 \text{ GeV}$ .

After the higgs mass reconstruction the remaining stable particles are used to find jets with C/A algorithm with  $\Delta R = 0.5$ ,  $p_T \geq 50 \text{ GeV}$ ,  $|\eta| \leq 2.5$  The Table III displays the robustness of  $R_T^{b\bar{b}}$  cut along with  $m_T(\ell, \not{p}_T)$  leading to a suppression of backgrounds to a negligible level without affecting signal significantly. Notice that after cuts sig-

Process	$\sigma(\text{pb})$	$N_{EV}$	$m_{b\bar{b}}$	Lepton	$M_T(\ell, \nu)$	$R_T^{b\bar{b}}$	$\not{p}_T$	c.s.
				$\geq 20$	$\geq 90$	$\geq 0.9$	$\geq 125$	(fb)
P1	0.175	25K	179	55	24	19	12	0.042
P2	0.065	10K	168	42	23	18	12	0.04
P3	0.03	10K	273	75	44	36	31	0.045
Wh	0.58	1M	871	239	12	11	0	0
Zh	0.3	2M	1698	37	0	0	0	0
$Wb\bar{b}$	3	619671	191	111	10	8	0	0
$Zb\bar{b}$	1.75	378086	81	13	0	0	0	0
$t\bar{t}$								
5-100	48.2	5M	1669	454	38	1	0	0
100-200	36.3	4M	1583	440	42	3	1	0.005
200-500	9.5	1M	315	98	9	2	0	0

TABLE III: Event summary for signal and backgrounds(method A) after each set of cuts described in the text. The  $t\bar{t}$  events are simulated for different  $\not{p}_T$  bins as shown. Efficiency for two b-tagged jets is multiplied in the last column. The energy units are in GeV.

nal cross sections remain the same for all cases although production cross sections decrease with the increase of gaugino masses, which is compensated by the increase of acceptance efficiencies. The total background cross section turn out to be 0.007 fb, an order of magnitude is less than the method A whereas signal cross sections are of the same level. Assuming  $100 \text{ fb}^{-1}$  luminosity, one can expect signal to background ratio  $S/\sqrt{B} \sim 7$  using NLO cross sections as before. It implies that probing the higgs signal in this channel is promising with 8 TeV LHC energy and high luminosity options. In both cases signal sensitivity is low because of the tiny production cross section in comparison with the backgrounds.

#### 4. SUMMARY

We investigate the discovery potential of a higgs signal in  $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$  production and its subsequent decay channels at 8 TeV LHC energy. This study is performed in the context of mSUGRA model taking into account the current higgs mass constraints predicted by recent measurements in CMS and ATLAS experiments. We simulate signal events in the final state with a single hard lepton and  $\not{p}_T$  along with a reconstructed higgs mass. The higgs mass reconstruction is performed following two ways, first by identifying b-jets using matching technique (method A) and secondly by using the method of jet substructures(method B). We present results for both cases and find that the latter method is more promising than the former one. We expect significance of about  $\sim 7$  for 250-400 GeV masses of  $\tilde{\chi}_1^\pm$  and  $\tilde{\chi}_2^0$  and  $m_h \sim 125 \text{ GeV}$  with  $100 \text{ fb}^{-1}$  luminosity by using jet substructure method. It is observed that results do not change significantly for other values of  $\tan \beta$ . In order to increase the sensitivity of higgs signal one needs to devise more effective selection

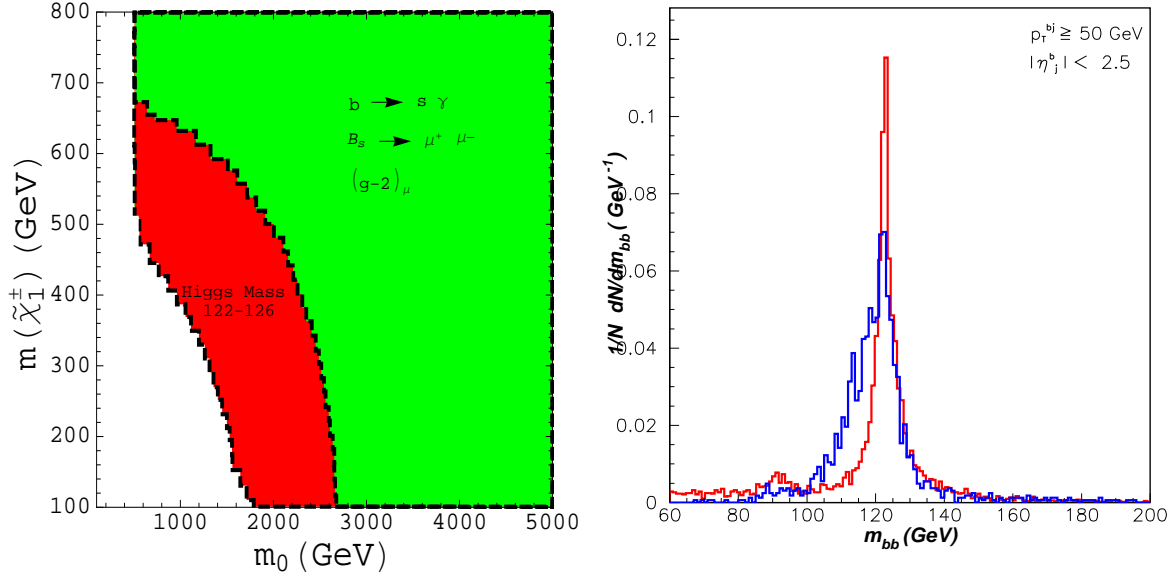


FIG. 1: The mSUGRA parameter space(left panel) allowed by all constraints(green) and by higgs mass constraints only(red) for  $\tan\beta=30$ . Range of scanned parameter space,  $m_0$ :0 to 5 TeV,  $A_0$ :0 to -5 TeV,  $m_{1/2}$ : 0 to 1 TeV. The higgs mass reconstruction(right panel) for method A (blue) and method B (red).

of cuts to isolate tiny signal events out of the huge backgrounds. If higgs is discovered it is worthwhile to study this channel to identify the model framework. The signal acceptance efficiency is dependent on the  $\Delta m$ , which is

sensitive to different models. Therefore, our conclusions are model specific and may be different in other models, particularly models where mass relations between gauginos follow differently.

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